DOE/OE Transmission Reliability Program

Load as a Resource: Building Loads for Ancillary Services

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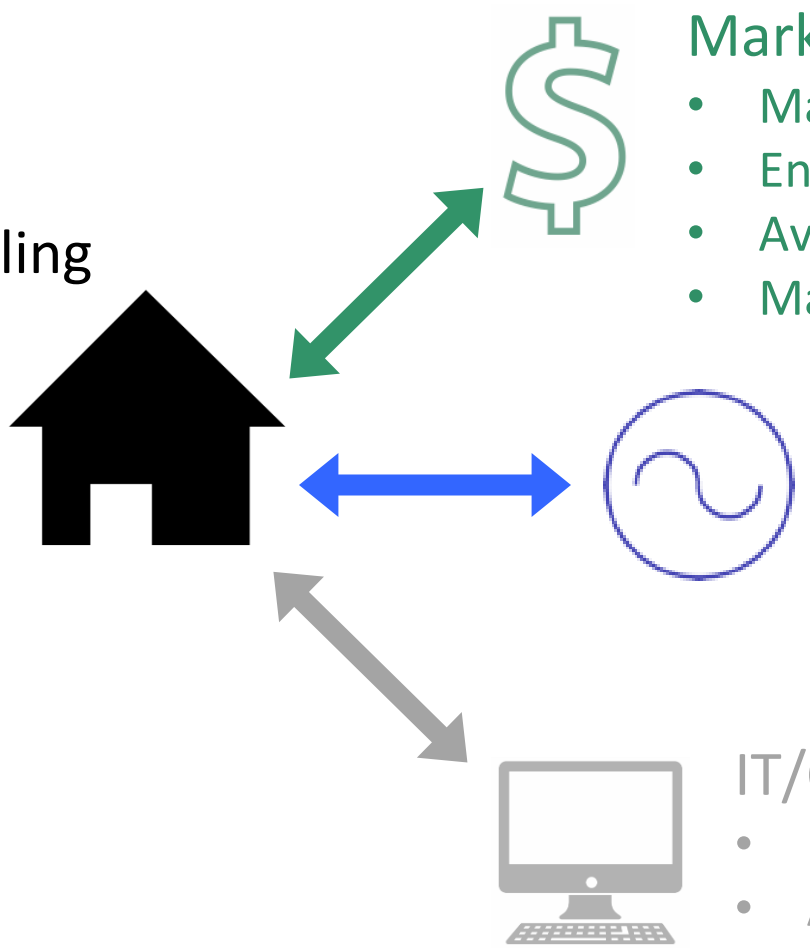
Overall Program Objectives



Market interactions
- Market Analysis
- Enablement costs
- Availability Prediction
- Marginal Cost

"Generator" Properties
- Response Speed
- Accuracy
- Controls Development
- Taxonomy

IT/Communications
- Protocol
- Architecture
- Security

LBNL's LaaR research aims to ***enable commercial building loads*** to provide market-based ***ancillary services***.

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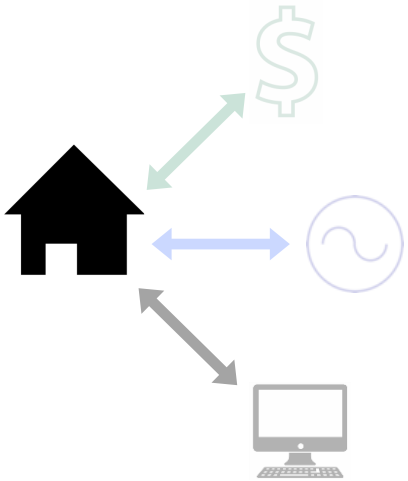
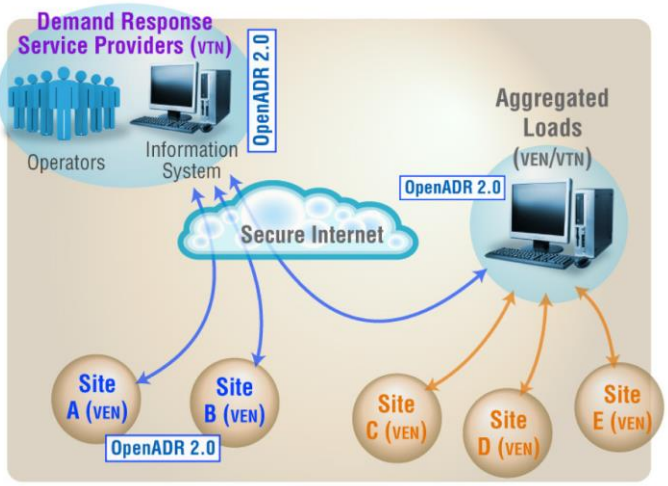
Looking Back – IT/Communications



Motivation (2011-2013):

- Standardized protocol for ***DR for AS***
- Evaluation of comm. latencies

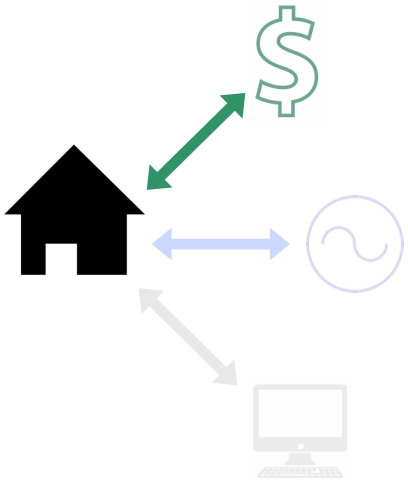
openADR ALLIANCE



Accomplishments:

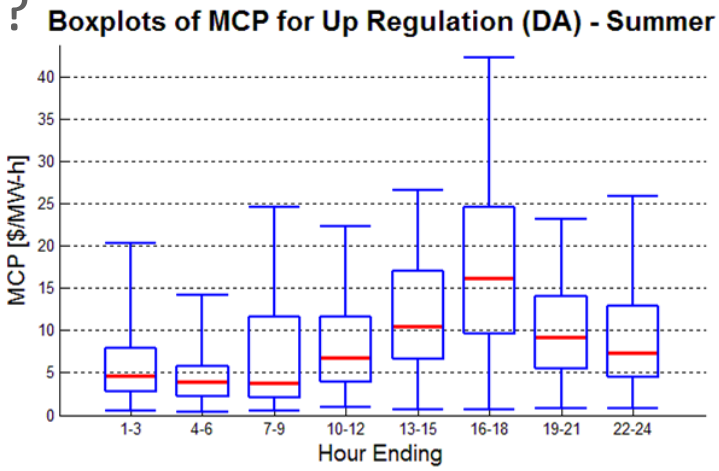
- OpenADR 2.0b developed in collaboration with OpenADR Alliance, vetted by ISO/RTO Council [FY11]
  - NIST National Smart Grid Standard, IEC-standard
  - ***>50*** 2.0b certified ***products commercially available***
- Evaluated OpenADR 2.0b communication latency:
  - in simulation [FY11] and ***demonstration with industry partner***, IPKeys (MacDonald et al, 2014)

Looking Back – DR for AS Economics



Motivation

- Potential revenue for DR for AS?
- What are the costs?



Southern California (2009-2012)

Accomplishments / Key Results:

- ISO/RTO AS market comparison
  - AS Opportunity between $5-26.5 / kW-mo with 24-7 participation
  - Publication received ***a best paper award*** (MacDonald et al, 2012)
- Compiled Enablement Costs for DR
  - ~$2000/site for small commercial (Kiliccote et al, 2014)

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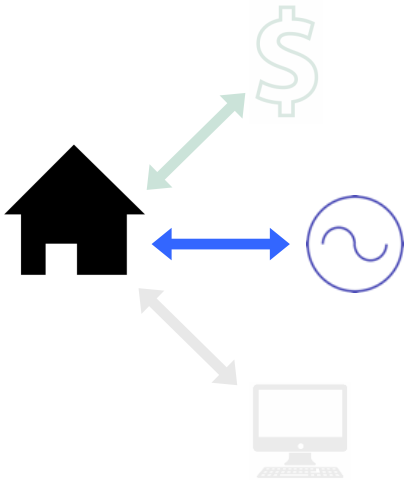
Looking Back – DR "Generator"



Motivation

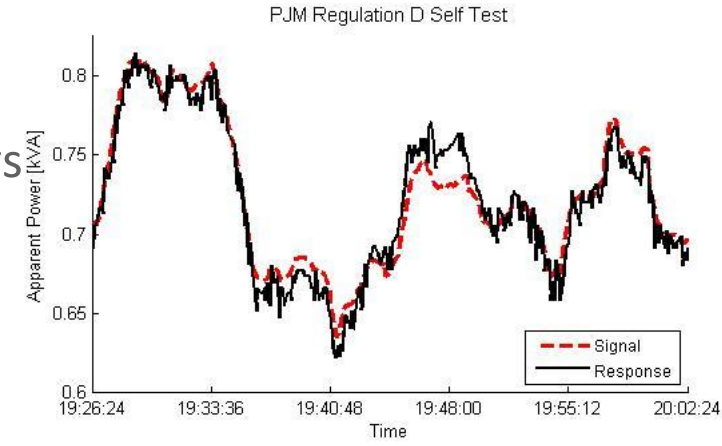
- Demonstrate Capability
- Quantify Accuracy + Response Time

IPKeys
SECURE TECHNOLOGY INTEGRATION
CONSULTING & SOFTWARE

Schneider Electric

Accomplishments / Key Results:

- Demonstrated DR for *Sync Reserve*
  - Industry Partners: Wal-Mart and IPKeys
  - DR from lighting
- Demonstrated DR for *Regulation*
  - Industry Partners: Schneider & IPKeys
  - HVAC fan w/ variable frequency drive
- Published: (MacDonald et al, 2014)



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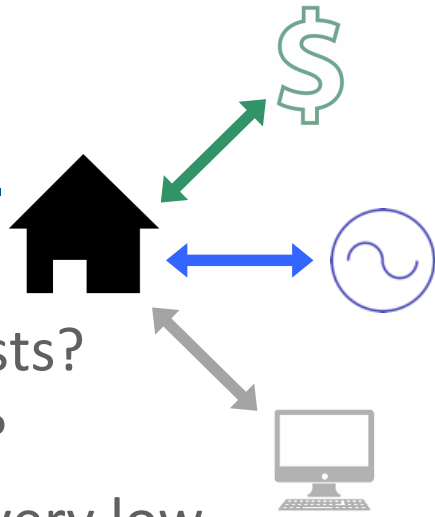
Taking stock: Key unknowns



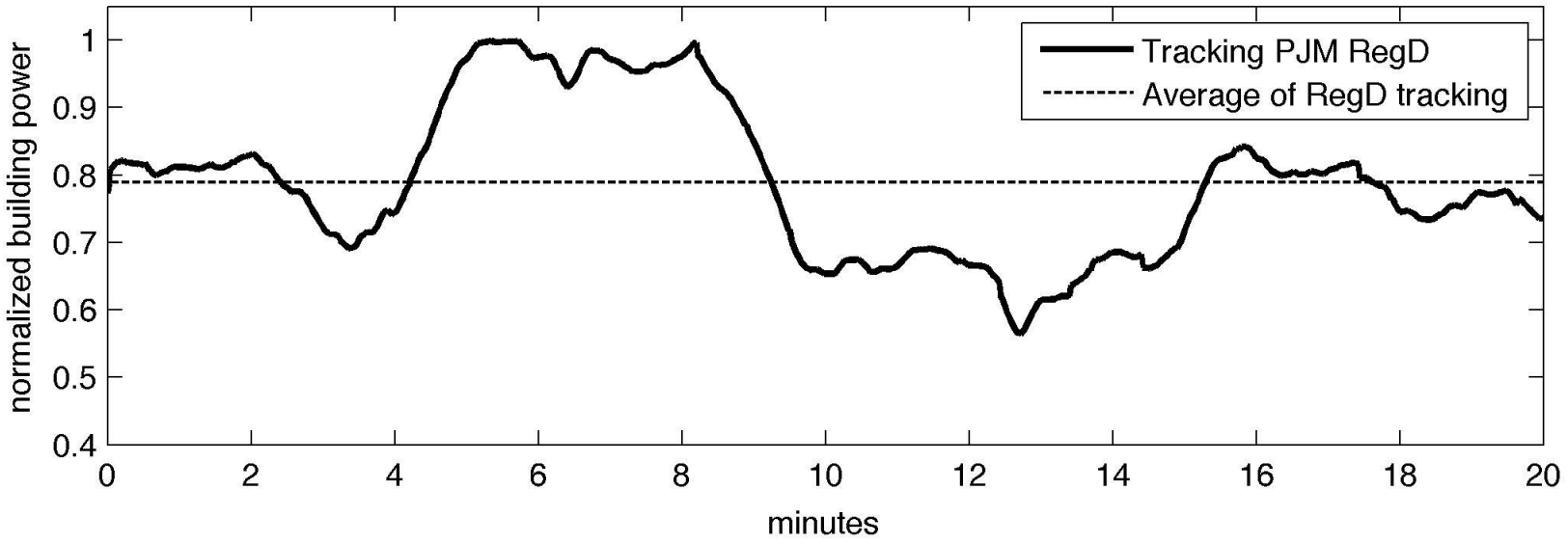
- We understand enablement costs and market potential, but are there ongoing opportunity costs?
  - If buildings are batteries, what's round trip efficiency?
- Partner tests: VFD tracking accuracy ~ 90% and very low latency. But what about total building systems? Need:
  - a perfect baseline
  - validated building models
  - state of the art control
  - End-to-end tracking of communications and actuation times
- If reserves are from space conditioning, how do occupant comfort and reserve offering interact?

LBNL FLEXLAB

- No occupants
- Four pairs of identical bays
- Variable speed chiller and fan
- Validated physics-based building models
- Extensive monitoring and submetering
- Transparent building energy management system
  - facilitates integration of advanced building control
- Access to PJM RegA and RegD signals in real time

Looking forward -- current stage in R&D cycle

FLEXLAB experiments: Second bay serves as "perfect" baseline (for computing opportunity cost and tracking performance)



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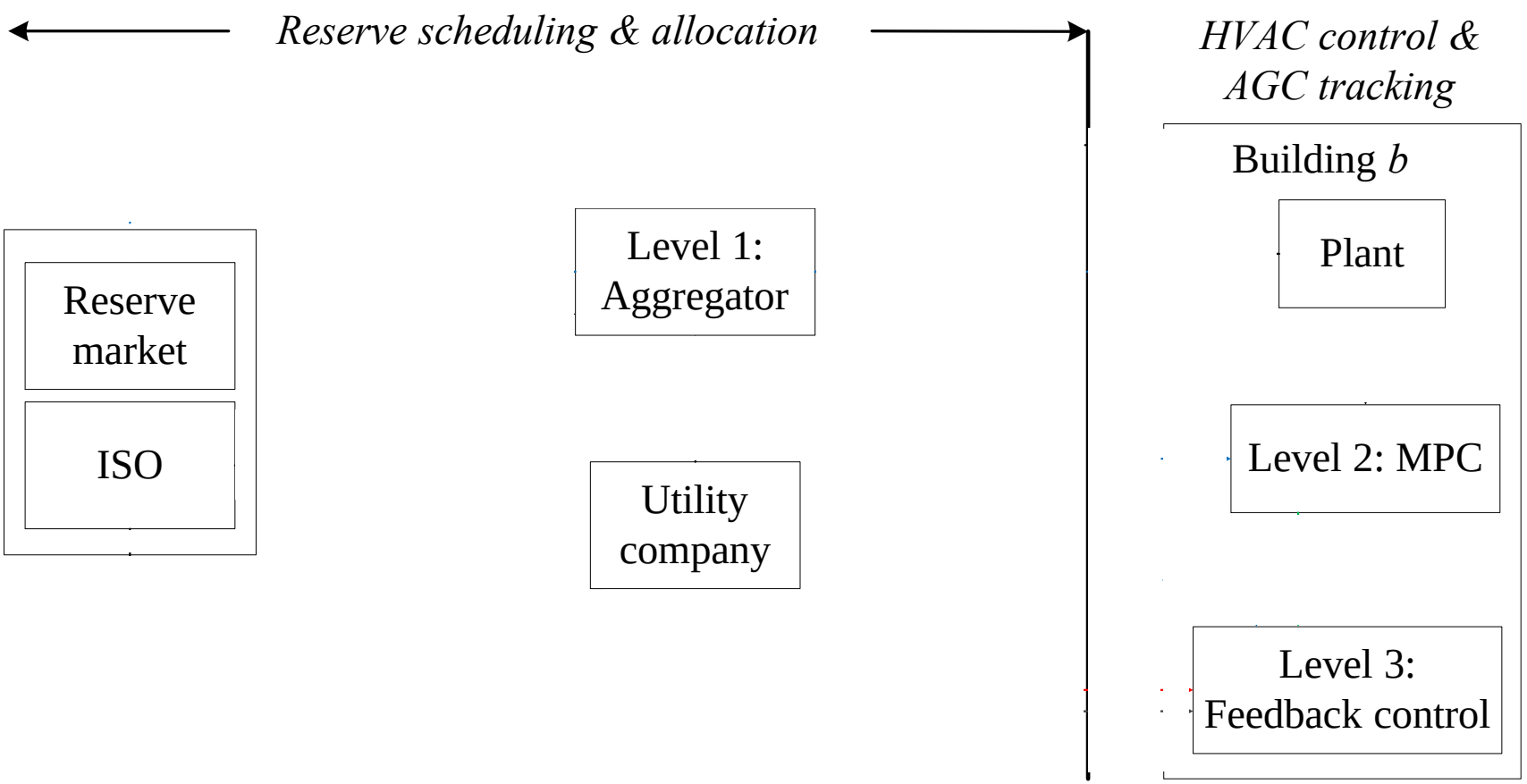
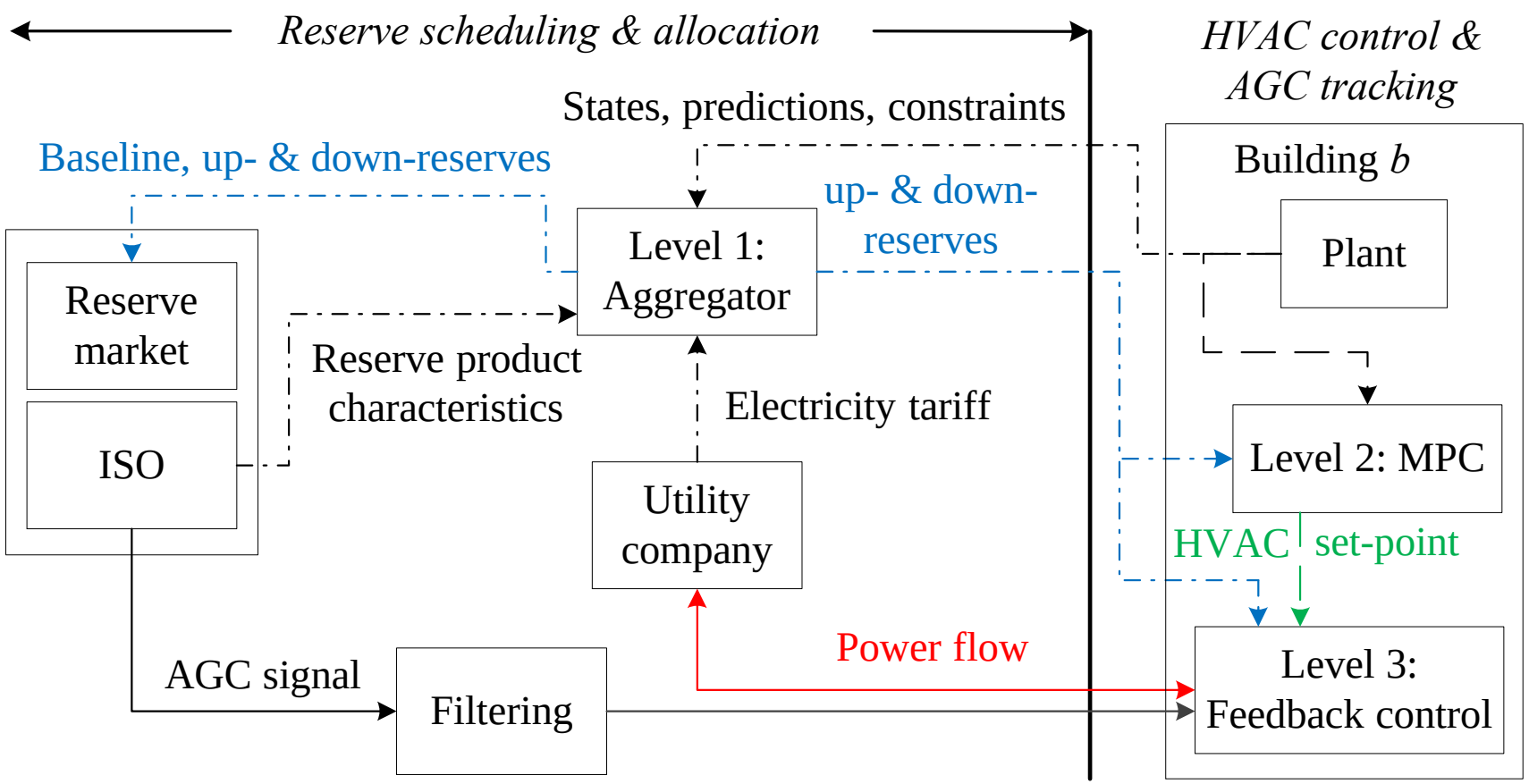
Hierarchical control scheme



Hierarchical control scheme



Looking forward: objectives

- FLEXLAB experiments complete this month
- Analysis complete by October
  - Quantify round trip efficiency of reg provision
  - Evaluate forecasting, optimization and control tool: accuracy
  - Quantify end-to-end latency, from PJM reg signal to change in power consumption
- Deliverables complete by January

Looking forward: Deliverables

- Conference publication on round trip reserve efficiency (operating cost) submitted November
- Draft technical report in December
- Journal publication evaluating forecasting tools, robust optimization and real time control submitted in Jan 2016

Risk Factors

- PJM communications hardware and software integration in a very short timeframe
  - Many communicating components in architecture
  - Could have controls read directly from historical data
- First experiment of this nature in FLEXLAB
  - Buildings and sensors may not perform as expected
  - Follow-on experiments in October, if needed
- Second FLEXLAB bay may not be perfect baseline
  - Use regression models to solve the problem

Potential follow-on work

- Work with other ISO's regulation signals
- Whole building demonstration w/ industrial partners
- Investigate tools to alleviate telemetry requirements
- Quantify and minimize post-reserve actuation dynamics ("rebound")
- Entire building plant control
  - Current experiments focus on supply fan
  - Chiller can also respond
  - Requires better building models, but yields more capacity

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Looking Back – Referenced Pubs

- MacDonald, Jason, Sila Kiliccote, Jim Boch, Jonathan Chen, Robert Nawy. *"Commercial Building Loads Providing Ancillary Services in PJM."* ACEEE Summer Study on Energy Efficiency in Buildings 2014. Asilomar Conference Center, Pacific Grove, CA, 2014

- MacDonald, Jason, Peter Cappers, Duncan S. Callaway, and Sila Kiliccote. "*Demand Response Providing Ancillary Services A Comparison of Opportunities and Challenges in the US Wholesale Markets.*" In Grid-Interop 2012. Irving, TX, 2012.

- Kiliccote, Sila, Steven Lanzisera, Anna Liao, Oren Schetrit, Mary Ann Piette. *"Fast DR: Controlling Small Loads over the Internet*." ACEEE Summer Study on Energy Efficiency in Buildings 2014. Asilomar Conference Center, Pacific Grove, CA, 2014.

Thank you

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